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OPERATIONAL MONITORING OF GLOBAL SNOW COVER: YEAR 2

Proposed continued contribution to the Climate Change Data and Detection Element's Applied Research Center, National Oceanic and Atmospheric Administration

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INTRODUCTION

We in the Rutgers University Global Snow Lab propose to continue our ongoing efforts to "take the pulse" of global snow cover distribution through renewed participation in the Climate Data and Detection Element's (CCDD) Applied Research Center (ARC). Lab members have been involved with the study of snow cover for more than 25 years, and for approximately the past 15 years the Rutgers Lab has been considered one of the primary locations to visit for data and knowledge pertaining to the distribution of snow cover across Northern Hemisphere lands. Support from the ARC will permit continued acquisition, quality control, archiving and dissemination of multiple data sets depicting the coverage and depth of snow on regional to continental scales. The ongoing focus is on maintaining the long-term daily (formerly weekly) data set of snow maps produced by NOAA. Within the next several years, an ongoing research project supported through CCDD's research program will permit the introduction of Southern Hemisphere snow data into the database, along with regional assessments of snow depth in the Northern Hemisphere. A means of blending the multiple data sources into a single snow product is also being introduced. Efforts in the years ahead will assure that the ingest, quality control and archiving of high quality data will continues, as will the addition of new products as they become available and the continued promotion and dissemination of all data products and assessments.

Ongoing ARC activities at the Global Snow Lab are addressed below in ARC template format.

BASIC DESCRIPTION OF DATA SETS

A. ***Specific variables:***

Snow extent and snow depth.

B. ***Type of observations used in data set production:***

1. NOAA Northern Hemisphere Interactive Multisensor Snow and Ice Mapping System (IMS) snow extent product, produced primarily from visual analyses of visible satellite imagery by trained meteorologists.
2. Microwave snow extent and depth product developed in cooperation with Thomas Mote (U. Georgia). Microwave snow maps of snow extent and depth are derived from a multispectral analysis of satellite data employing frequency gradients.
3. Station snow depth observations from U.S., Canadian, and when and where possible to obtain, from Eurasian and some Southern Hemisphere nations.

C. ***Geographic area covered:***

Northern and Southern Hemisphere continents.

D. *Temporal and spatial resolution of data sets:*

Each source is mapped at a 1-degree spatial resolution on a daily basis. Pentad, and monthly products are also being generated. Future improvements of spatial resolution may follow. Individual data sources will be available at higher spatial resolutions, including point station observations. It is unlikely that products at sub-daily temporal resolutions will be produced.

E. *Duration of the data sets:*

1. NOAA snow: Weekly from November 1966 through May 1999, daily since June 1999.
2. Microwave: Daily from 1987 to present (some temporal gaps remain at this time, but, as much as is possible, we hope to remedy this in the coming year, but no better than every pentad from 1979 to 1987.
3. Station: To vary by country, however data from some United States and Canadian stations is available back to 1900 through the present. Data from other nations is likely only available in recent decades.

F. *Standard interval for adding new data:*

1. NOAA snow: Data are being updated monthly, one to two weeks following the end of a given month. Plans are underway to add daily and weekly analyses.
2. Microwave: Once available operationally, microwave products will be updated quarterly, perhaps more frequently should more timely data become available for processing.
3. Station: Once available operationally, U.S. data will be updated as close to quarterly as possible, likely with delays of data of a month or two from the end of a quarter. Observations from other nations are likely to have more substantial delays. However, efforts will be made early in the project to commence ingesting GTS data on a daily basis, along with more timely U.S. observations from as many Cooperative stations as possible.

G. *Mechanisms for accessing data:*

Protocols will be developed to pull data electronically from necessary sources via the Internet. It may also be necessary to ask for certain data sets to be pushed to us electronically. When possible, this will be done in an automated manner.

H. *Current uses of data sets that support operational designation:*

Timely, accurate and spatially complete snow information is required for monthly, seasonal and annual national and global climate assessments produced by NCDC and others. Such assessments are published in the Bulletin of the American Meteorological Society and elsewhere. Information is also needed for longer-term IPCC assessments. Operational snow data are also valuable input to weather and climate forecasting efforts.

SCIENTIFIC STEWARDSHIP ACTIVITIES REQUIRED FOR THE CONTINUED PRODUCTION OF THE CLIMATE-QUALITY DATA SET

A. *Quality control procedures:*

Quality control/assurance of the NOAA weekly visible data set extends back to the late 1970s and early 1980s when the Principal Investigator collaborated with George Kukla on several investigations. These efforts have continued intermittently since then, including quality control efforts during the remapping of the late 1960s and early 1970s data. However, quality control to date has been insufficient. This will change with the availability of the multiple visible, microwave and station data sets, all mapped to common temporal and spatial resolutions. This will facilitate blending of the sets, and also intercomparisons using GIS methodologies. Such comparisons will be conducted under the Snow ARC and also under a snow mapping development effort currently being funded by the research element of CCDD. The research effort has Snow ARC lead Robinson and Thomas Mote of the University of Georgia as co-PIs. We are confident that these procedures will identify major strengths and weaknesses of the individual products by region and time of year. It may also lead to adjustments in our microwave and station snow mapping

routines (full reanalyses will be undertaken if this is found to be the case) (cf. B below). It should also permit error margins to be placed on the NOAA weekly product, and used to suggest improvements to the visible IMS mapping methodology.

B. *Bias identification and processing:*

Through the thorough quality control/assurance effort described in the previous paragraph potential biases of each snow product should be identified. Should persistent biases be identified, efforts within the Snow ARC and CCDD research project will attempt to remedy the situation. Also, as part of the research project, Landsat and MODIS imagery will be obtained for several periods over recent years. Areas covered with snow will be charted from these images and compared with station data, and visible and microwave maps. Northern Hemisphere study regions will have relatively abundant station data. Southern Hemisphere study sites with available station data will also be sought. A daily operational visible product is not available over the Southern Hemisphere.

C. *Reprocessing work underway:*

Several years ago, CCDD support permitted the reanalysis of the 1967-71 NOAA weekly maps at the Rutgers Climate Lab. This greatly improved maps for that interval. No further reanalyses are expected in upcoming years.

Under the coincident Robinson and Mote research project, a new, hybrid microwave snow mapping algorithm is being developed and tested. We anticipate that an operational product will be available for the Snow ARC by the end of the three-year research grant period. Briefly, snow covered areas are designated by the 22V - 85V GHz frequency gradient greater than 5K. Regions of melting snow are identified by small 19GHz and 37GHz polarization differences (5K and 10K, respectively) or when a critical 37V brightness temperature is exceeded. Snow depths are calculated based on a linear regression of observed snow depths to the 19-37V frequency gradient and the maximum snow covered albedo, which serves as a proxy for vegetation cover. The 22/85 gradient is based on the work of Grody and Basist. There is more to it than that, but that criterion drives most of the snow identification. The polarization differences are from Walker's work. The remainder is based on our current or previous findings.

Daily observations from US and Canadian Cooperative Observing stations have been assembled into a database, and a simple “drop in the bucket” method has been used to construct daily 1^{o} x 1^{o} maps of snow cover from 1950 through 2001 (pentad maps are available at: http://climate.rutgers.edu/snowcover) Summary statistics are available for each grid cell provided, including area covered and maximum and minimum snow depth. We will acquire Former Soviet Union daily data from the 20^{th} century and will map this too. Additional Eurasian data will also be sought from European and Chinese sources.

D. *“Hands-on” utilization activities:*

The NOAA snow map series has frequently been updated at Rutgers over the past 15 years (http://climate.rutgers.edu/snowcover). Along with numerous colleagues, Robinson has exercised the data set in dozens of manuscripts. So too have many scientists acquired the data and used it in their studies. In recent years, several dozen scientists have retrieved the full data set from the Climate Lab server. Numerous others have visited the web site to view and use the data and information provided on the site. Such open access will be continued for all data sets maintained within the Snow ARC. Follow ups with those using the data will be undertaken, and remedial actions undertaken should problems with a data set, the archive or information delivery be encountered.

E. *“Point Man”:*

The Principal Investigator is considered a major “champion” of the NOAA snow map products since 1990 and has worked with these visible maps since the late 1970s. The Rutgers Global Snow Lab is recognized as an international focal point for the evaluation of snow kinematics and snow-climate interactions and archive of snow data. Robinson has and will continue to publish extensively, utilizing the NOAA data and other data sets produced as a result of Snow ARC

activities and other prior and ongoing efforts. He will be the key "point man" for Snow ARC activities.

TRANSITION OF ARC PROJECT TO OPERATIONAL CENTER

A. NOAA daily/weekly visible product

Discussions are ongoing with colleagues at the National Climate Data Center for the smooth transition of Snow ARC operational endeavors to Asheville. This will first include providing NCDC with the archive of weekly and monthly visible snow products from the Rutgers Global Snow Lab. This will be accomplished this spring. Following this, a means will be established to frequently update the NCDC archive, while processing of the visible product remains at Rutgers. By next year, Rutgers software will be documented and provided to NCDC for trial processing of the visible product at NCDC in year 3 of the ARC arrangement. Year 3 and beyond will see a continuation of Robinson's stewardship of the NOAA visible product. This is critical, as this product is likely to evolve in the coming years, and history has shown that the maintenance of a temporally consistent product and resultant analyses is highly dependent on a product "watch dog".

B. Station and microwave products

Transitioning of operational station and microwave products to NCDC will continue over the next several years. These activities will follow behind the visible product. It will take some time to establish an operational feed of station and microwave data to the Rutgers Global Snow Lab and from there produce daily/weekly/monthly maps and analyses. We are dependent on NCDC and the Meteorological Service of Canada for the availability of station data (forgoing data from other nations for the time being) and will seek the most rapid means of acquiring microwave data.

C. Blended products

Finally, routines to blend the visible, microwave and station data will be transitioned to NCDC. This will not be accomplished for at least several years. Again, ongoing stewardship of this endeavor is critical to maintaining a consistent product.